SCIENCE

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THE ELECTRO-MAGNET.[1]

Introductory.

AMONG the great inventions which have originated in the lecture-room in which we are met are two of special interest to electricians,—the application of gutta-percha to the purpose of submarine telegraph-cables, and the electro-magnet. This latter invention was first publicly described from the very platform on which I stand, on May 23, 1825, by William Sturgeon, whose paper is to be found in the forty-third volume of the "Transactions of the Society of Arts." For this invention we may rightfully claim the very highest place. Electrical engineering, the latest and most vigorous offshoot of applied science, embraces many branches. The dynamo for generating electric currents, the motor for transforming their energy back into work, the arc-lamp, the electric bell, the telephone, the recent electro-magnetic machinery for coal-mining, for the separation of ore, and many other electro-mechanical contrivances, come within the purview of the electrical engineer. In every one of these, and in many more of the useful applications of electricity, the central organ is an electro-magnet. By means of this simple and familiar contrivance,—an iron core surrounded by a copper-wire coil,—mechanical actions are produced at will, at a distance, under control, by the agency of electric currents. These mechanical actions are known to vary with the mass, form, and quality of the iron core, the quantity and disposition of the copper wire wound upon it, the quantity of electric current circulating around it, the form, quality, and distance of the iron armature upon which it acts. But the laws which govern the mechanical action in relation to these various matters are by no means well known; and, indeed, several of them have long been a matter of dispute. Gradually, however, that which has been vague and indeterminate becomes clear and precise. The laws of the steady circulation of electric currents, at one time altogether obscure, were cleared up by the discovery of the famous law of Ohm. Their extension to the case of rapidly interrupted currents, such as are used in telegraphic working, was discovered by Helmholtz; while to Maxwell is due their further extension to alternating, or, as they are sometimes called, undulatory currents. All this was purely electric work. But the law of the electro-magnet was still undiscovered; the magnetic part of the problem was still buried in obscurity. The only exact reasoning about magnetism dealt with problems of another kind; it was couched in language of a misleading character; for the practical problems connected with the electro-magnet it was worse than useless,—the doctrine of two magnetic fluids distributed over the end surfaces of magnets, which, under the sanction of the great names of Coulomb, of Poisson, and of Laplace, had unfortunately become recognized as an accepted part of science, along with the law of inverse squares. How greatly the progress of electro-magnetic science has been impeded and retarded by the weight of these great names, it is impossible now to gauge. We now know that for all purposes, save only those whose value lies in the domain of abstract mathematics, the doctrine of the two magnetic fluids is false and misleading. We know that magnetism, so far from residing on the end or surface of the magnet, is a property resident throughout the mass; that the internal, not the external, magnetization is the important fact to be considered; that the so-called free magnetism on the surface is, as it were, an accidental phenomenon; that the magnet is really most highly magnetized at those parts where there is least surface magnetization; finally, that the doctrine of surface distribution of fluids is absolutely incompetent to afford a basis of calculation such as is required by the electrical engineer. He requires rules to enable him not only to predict the lifting power of a given electro-magnet, but also to guide him in designing and constructing electro-magnets of special forms suitable for the various cases that arise in his practice. He wants in one place a strong electro-magnet to hold on to its armature like a limpet to its native rock; in another case he desires a magnet having a very long range of attraction, and wants a rule to guide him to the best design; in another he wants a special form having the most rapid action attainable; in yet another he must sacrifice every thing else to attain maximum action with minimum weight. Toward the solution of such practical problems as these, the old theory of magnetism offered not the slightest aid. Its array of mathematical symbols was a mockery. It was as though an engineer asking for rules to enable him to design the cylinder and piston of an engine were confronted with receipts how to estimate the cost of painting it.

Gradually, however, new light dawned. It became customary, in spite of the mathematicians, to regard the magnetism of a magnet as something that traverses or circulates around a definite path, flowing more freely through such substances as iron than through other relatively non-magnetic materials. Analogies between the flow of electricity in an electrically conducting circuit, and the passage of magnetic lines of force through circuits possessing magnetic conductivity, forced themselves upon the minds of experimenters, and compelled a mode of thought quite other than the pre-

[1] Lecture delivered Jan. 20, 1890, by Professor Silvanus P. Thompson, before the Society of Arts, London.

viously accepted. So far back as 1821, Cumming[1] experimented on magnetic conductivity. The idea of a magnetic circuit was more or less familiar to Ritchie,[2] Sturgeon,[3] Dove,[4] Dub,[5] and De la Rive,[6] the last named of whom explicitly uses the phrase "a closed magnetic circuit." Joule[7] found the maximum power of an electro-magnet to be proportional to "the least sectional area of the entire magnetic circuit," and he considered the resistance to induction as proportional to the length of the magnetic circuit. Indeed, there are to be found scattered in Joule's writings on the subject of magnetism some five or six sentences, which, if collected together, constitute a very full statement of the whole matter. Faraday[8] considered that he had proved that each demagnetic line of force constitutes a closed curve; that the path of these closed curves depended on the magnetic conductivity of the masses disposed in proximity; that the lines of magnetic force were strictly analogous to the lines of electric flow in an electric circuit. He spoke of a magnet surrounded by air being like unto a voltaic battery immersed in water or other electrolyte. He even saw the existence of a power analogous to that of electro-motive force in electric circuits, though the name "magneto-motive force" is of more recent origin. The notion of magnetic conductivity is to be found in Maxwell's great treatise (vol. ii. p. 51), but is only briefly mentioned. Rowland,[9] in 1873, expressly adopted the reasoning and language of Faraday's method in the working-out of some new results on magnetic permeability, and pointed out that the flow of magnetic lines of force through a bar could be subjected to exact calculation. The elementary law, he says, "is similar to the law of Ohm." According to Rowland, the "magnetizing force of helix" was to be divided by the "resistance to the lines of force,"—a calculation for magnetic circuits which every electrician will recognize as precisely as Ohm's law for electric circuits. He applied the calculations to determine the permeability of certain specimens of iron, steel, and nickel. In 1882,[10] and again in 1883, Mr. R. H. M. Bosanquet[11] brought out at greater length a similar argument, employing the extremely apt term "magneto-motive force" to connote the force tending to drive the magnetic lines of induction through the "magnetic resistance," or, as it will be frequently called in these lectures, the "magnetic reluctance" of the circuit. In these papers the calculations are reduced to a system, and deal not only with the specific properties of iron, but with problems arising out of the shape of the iron. Bosanquet shows how to calculate the several resistances (or reluctances) of the separate parts of the circuit, and then add them together to obtain the total resistance (or reluctance) of the magnetic circuit.

[1] Cambridge Philosophical Transactions, April 2, 1821.

[2] Philosophical Magazine, series iii. vol. iii. p. 122.

[3] Annals of Electricity, xii. p. 217.

[4] Poggendorf's Annalen, 1833, xxix. p. 462; 1838, xliii. p. 517.

[5] Dub's Elektromagnetismus (ed. 1861), p. 401; Poggendorf's Annalen, 1853, xc. p. 440.

[6] De la Rive's Treatise on Electricity (Walker's translation), i. p. 292.

[7] Annals of Electricity, 1839, iv. p. 59; *Ibid*, 1841, v. p. 195; Scientific Papers, pp. 8, 34, 35, 36

[8] Experimental Researches, iii. arts. 3117, 3228, 3230, 3260, 3271, 3276, 3294, and 3361.

[9] Philosophical Magazine, series iv. vol. xlvi. August, 1873, "On Magnetic Permeability and the Maximum of Magnetism of Iron, Steel, and Nickel."

[10] Proceedings of the Royal Society, xxxiv. p. 445, December, 1882

[11] Philosophical Magazine, series v. vol. xv. p. 205, March, 1883, 'On Magneto-Motive Force;" *Ibid*, xix. February, 1885; Proceedings of the Royal Society, 1883, No. 223; Electrician, xiv. p. 291, Feb. 14, 1885.

Prior to this, however, the principle of the magnetic circuit had been seized upon by Lord Elphinstone and Mr. Vincent, who proposed to apply it in the construction of the dynamo-electric machines. On two occasions[1] they communicated to the Royal Society the results of experiments to show that the same exciting current would evoke a larger amount of magnetism in a given iron structure if that iron structure formed a closed magnetic circuit than if it were otherwise disposed.

In recent years the notion of the magnetic circuit has been vigorously taken up by the designers of dynamo-machines, who indeed base the calculation of their designs upon this all-important principle. Having this, they need no laws of inverse squares of distances, no magnetic moments, none of the elaborate expressions for surface distribution of magnetism, none of the ancient paraphernalia of the last century. The simple law of the magnetic circuit and a knowledge of the properties of iron are practically all they need. About four years ago, much was done by Mr. Gisbert Kapp[2] and by Drs. J. and E. Hopkinson[3] in the application of these considerations to the design of dynamo-machines, which previously had been a matter of empirical practice. To this end the formulæ of Professor Forbes[4] for calculating magnetic leakage, and the researches of Professors Ayrton and Perry[5] on magnetic shunts, contributed a not unimportant share. As the result of the advances made at that time, the subject of dynamo design was reduced to an exact science.

It is the aim and object of the present course of lectures to show how the same considerations which have been applied with such great success to the subject of the design of dynamo-electric machines may be applied to the study of the electro-magnet. The theory and practice of the design and construction of electro-magnets will thus be placed, once for all, upon a rational basis. Definite rules will be laid down for the guidance of the constructor, directing him as to the proper dimensions and form of iron to be chosen, and as to the proper size and amount of copper wire to be wound upon it in order to produce any desired result.

First, however, an historical account of the invention will be given, followed by a number of general considerations respecting the uses and forms of electro-magnets. These will be followed by a discussion of the magnetic properties of iron and steel and other materials, some account being added of the methods used for determining the magnetic permeability of various brands of iron at different degrees of saturation. Tabular information is given as to the results found by different observers. In connection with the magnetic properties of iron, the phenomenon of magnetic hysteresis is also described and discussed. The principle of the magnetic circuit is then discussed with numerical examples, and a number of experimental data respecting the performance of electro-magnets are adduced, in particular those bearing upon the tractive power of electro-magnets. The law of traction between an electro-magnet and its armature

[1] Proceedings of the Royal Society, 1879, xxix. p. 292; *Ibid*, 1880, xxx. p. 287; Electrical Review, 1880, viii. p. 134.

[2] The Electrician, 1885-86, xiv. xv. xvi.; Proceedings of the Institute of Civil Engineers, 1885-86, lxxxiii.; Journal of the Society of Telegraphic Engineers, 1886, xv. p. 524.

[3] Philosophical Transactions, 1886, part i. p. 331; The Electrician, 1886, xviii. pp. 39, 63, 86.

[4] Journal of the Society of Telegraphic Engineers, 1886, xv. p. 555.

[5] *Ibid*, p. 530.

is then laid down, followed by the rules for predetermining the iron cores and copper coils required to give any prescribed tractive force.

Then comes the extension of the calculation of the magnetic circuit to those cases where there is an air-gap between the poles of the magnet and the armature, and where, in consequence, there is leakage of the magnetic lines from pole to pole. The rules for calculating the winding of the copper coils are stated, and the limiting relation between the magnetizing power of the coil and the heating effect of the current in it is explained. After this comes a detailed discussion of the special varieties of form that must be given to electro-magnets in order to adapt them to special services. Those which are designed for maximum traction, for quickest action, for longest range, for greatest economy when used in continuous daily service, for working in series with constant current, for use in parallel at constant pressure, and those for use with alternate currents, are separately considered.

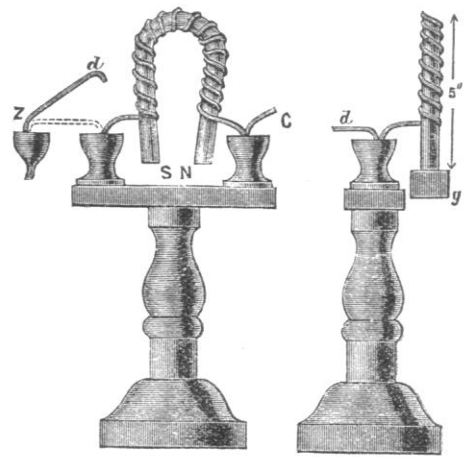
Lastly, some account is given of the various forms of electro-magnetic mechanism which have arisen in connection with the invention of the electro-magnet. The plunger and coil is specially considered as constituting a species of electro-magnet adapted for a long range of motion. Modes of mechanically securing long range for electro-magnets, and of equalizing their pull over the range of motion of the armature, are also described. The analogies between sundry electro-mechanical movements and the corresponding pieces of ordinary mechanism are traced out. The course is concluded by a consideration of the various modes of preventing or minimizing the sparks which occur in the circuits in which electro-magnets are used.

Historical Sketch.

The effect which an electric current, flowing in a wire, can exercise upon a neighboring compass-needle was discovered by Oersted in 1820.[1] This first announcement of the possession of magnetic properties by an electric current was followed speedily by the researches of Ampère,[2] Arago,[3] Davy,[4] and by the devices of several other experimenters, including De la Rive's[5] floating battery and coil, Schweigger's[5] multiplier, Cumming's[6] galvanometer, Faraday's[7] apparatus for rotation of a permanent magnet, Marsh's[8] vibrating pendulum, and Barlow's[8] rotating star-wheel. But it was not until 1825 that the electro-magnet was invented. Davy had, indeed, in 1821, surrounded with temporary coils of wire the steel needles upon which he was experimenting, and had shown that the flow of electricity around the coil could confer magnetic power upon the steel needles. But from this experiment it was a grand step forward to the discovery that a core of soft iron, surrounded by its own appropriate coil of copper, could be made to act not only as a powerful magnet, but as a magnet whose power could be turned on or off at will, could be augmented to any desired degree, and could be set into action and controlled from a practically unlimited distance.

[1] Thomson's Annals of Philosophy, October, 1820.
[2] Ann. de Chim. et de Physique, 1820, xv. pp. 59, 170.
[3] *Ibid*, p. 93.
[4] Philosophical Transactions, 1821.
[5] Bibliothèque Universelle, March, 1821.
[6] Cambridge Philosophical Transactions, 1821.
[7] Quarterly Journal of Science, September, 1821.
[8] Barlow's Magnetic Attractions, 1823 (2d ed.).

The electro-magnet, in the form which can first claim recognition for these qualities, was devised by William Sturgeon,[1] and is described by him in the paper which he contributed to the "Proceedings of the Society of Arts" in 1825, accompanying a set of improved apparatus for electro-magnetic experiments.[2] The Society of Arts rewarded Sturgeon's labors by awarding him the silver medal of the society and a premium of thirty guineas. Among this set of apparatus are two electro-magnets,—one of horseshoe shape (Figs. 1 and 2), and one a straight bar (Fig. 3). It will be seen that the former figures represent an electro-magnet consisting of a bent iron rod about one foot long, and half an inch in diameter, varnished over, and then coiled with a single left handed spiral of stout uncovered copper wire of 18 turns. This coil was found appropriate to the particular battery which Sturgeon preferred, namely, a single cell containing a spirally enrolled pair of zinc and copper plates of large area (about 130 square inches) immersed in acid; which cell, having small internal resistance, would yield a large quantity of current when connected to a circuit of



FIGS. 1 AND 2.—STURGEON'S FIRST ELECTRO-MAGNET.

small resistance. The ends of the copper wire were brought out sideways, and bent down so as to dip into two deep connecting cups, marked *Z* and *C*, fixed upon a wooden stand. These cups, which were of wood, served as supports to hold up the electro-magnet, and, having mercury in them, served also to make good electrical connection. In Fig. 2 the mag-

[1] William Sturgeon, the inventor of the electro-magnet, was born at Whittington, in Lancashire, in 1783. Apprenticed as a boy to the trade of a shoemaker, at the age of nineteen he joined the Westmoreland Militia, and two years later enlisted into the Royal Artillery, thus gaining the chance of learning something of science, and having leisure in which to pursue his absorbing passion for chemical and physical experiments. He was forty-two years of age when he made his great, though at the time unrecognized, invention. At the date of his researches in electro-magnetism he was resident at 8 Artillery Place, Woolwich, at which place he was the associate of Marsh, and was intimate with Barlow, Christie, and Gregory, who interested themselves in his work. In 1835 he presented a paper to the Royal Society containing descriptions, *inter alia*, of a magneto-electric machine with longitudinally wound armature, and with a commutator consisting of half disks of metal. For some reason this paper was not admitted to the Philosophical Transactions. He afterwards printed it in full, without alteration, in his volume of Scientific Researches, published by subscription in 1850. From 1836 to 1843 he conducted the Annals of Electricity. He had now removed to Manchester, where he lectured on electricity at the Royal Victoria Gallery. He died at Prestwich, near Manchester, in 1850. There is a tablet to his memory in the church at Kirkby Lonsdale, from which town the village of Whittington is distant about two miles. A portrait of Sturgeon in oils, said to be an excellent likeness, is believed still to be in existence; but all inquiries as to its whereabouts have proved unavailing. At the present moment, so far as I am aware, the scientific world is absolutely without a portrait of the inventor of the electro-magnet.

[2] Transactions of the Society of Arts, 1825, xliii. p. 38.

net is seen sideways, supporting a bar of iron, *y*. The circuit was completed to the battery through a connecting wire, *d*, which could be lifted out of the cup *Z*, so breaking circuit when desired, and allowing the weight to drop. Sturgeon added in his explanatory remarks that the poles, *N* and *S*, of the magnet will be reversed if you wrap the copper wire about the rod as a right-handed screw instead of a left-handed one, or, more simply, by reversing the connec-

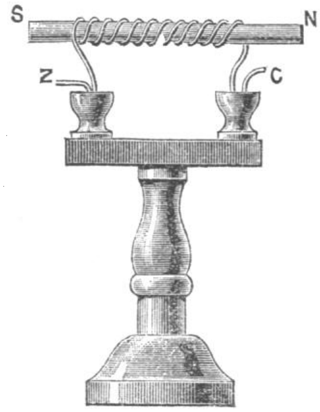


FIG. 3.—STURGEON'S STRAIGHT-BAR ELECTRO-MAGNET.

tions with the battery, by causing the wire that dips into the *Z* cup to dip into the *C* cup, and *vice versa*. This electro-magnet was capable of supporting nine pounds when thus excited.

Fig. 3 shows another arrangement to fit on the same stand. This arrangement communicates magnetism to hardened steel bars as soon as they are put in, and renders soft iron within it magnetic during the time of action. It only differs

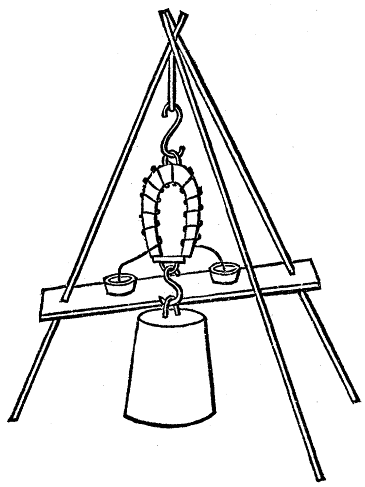


FIG. 4.—STURGEON'S LECTURE-TABLE ELECTRO-MAGNET.

from Figs. 1 and 2 in being straight, and thereby allows the steel or iron bars to slide in and out.

For this piece of apparatus and other adjuncts accompanying it, all of which are described in the society's "Transactions" for 1825, Sturgeon, as already stated, was awarded the society's silver medal and a premium of thirty guineas. The apparatus was deposited in the museum of the society, which therefore might be supposed to be the proud possessor of the first electro-magnet ever constructed. Alas for the vanity of human affairs! the society's museum of apparatus has long been dispersed, this priceless relic having been either made over to the now defunct Patent Office Museum, or otherwise lost sight of.

Sturgeon's first electro-magnet, the core of which weighed about 7 ounces, was able to sustain a load of 9 pounds, or about twenty times its own weight. At the time it was considered a truly remarkable performance. Its single layer of stout copper wire was well adapted to the battery employed, a single cell of Sturgeon's own particular construction having a surface of 130 square inches, and therefore of small internal resistance. Subsequently, in the hands of Joule, the same electro-magnet sustained a load of 50 pounds, or about a hundred and fourteen times its own weight. Writing in 1832 about his apparatus of 1825, Sturgeon used the following magniloquent language:—

"When first I showed that the magnetic energies of a galvanic conducting wire are more conspicuously exhibited by exercising them on soft iron than on hard steel, my experiments were limited to small masses, generally to a few inches of rod-iron about half an inch in diameter. Some of those pieces were employed while straight, and others were bent into the form of a horseshoe magnet, each piece being encompassed by a spiral conductor of copper wire. The magnetic energies developed by these simple arrangements are of a very distinguished and exalted character, as is conspicuously manifested by the suspension of a considerable weight at the poles during the period of excitation by the electric influence.

"An unparalleled transiliency of magnetic action is also displayed in soft iron by an instantaneous transition from a state of total inactivity to that of vigorous polarity, and also by a simultaneous reciprocity of polarity in the extremities of the bar,—versatilities in this branch of physics for the display of which soft iron is pre-eminently qualified, and which, by the agency of electricity, become demonstrable with the celerity of thought, and illustrated by experiments the most splendid in magnetics. It is, moreover, abundantly manifested by ample experiments that galvanic electricity exercises a superlative degree of excitation on the latent magnetism of soft iron, and calls for its recondite powers with astonishing promptitude, to an intensity of action far surpassing any thing which can be accomplished by any known application of the most vigorous permanent magnet, or by any other mode of experimenting hitherto discovered. It has been observed, however, by experimenting on different pieces selected from various sources, that, notwithstanding the greatest care be observed in preparing them of a uniform figure and dimensions, there appears a considerable difference in the susceptibility which they individually possess of developing the magnet powers, much of which depends upon the manner of treatment at the forge, as well as upon the natural character of the iron itself.[1]

"The superlative intensity of electro-magnets, and the facility and promptitude with which their energies can be

[1] "I have made a number of experiments on small pieces, from the results of which it appears that much hammering is highly detrimental to the development of magnetism in soft iron, whether the exciting cause be galvanic or any other; and although good annealing is always essential, and facilitates to a considerable extent the display of polarity, that process is very far from restoring to the iron that degree of susceptibility which it frequently loses by the operation of the hammer. Cylindric rod-iron of small dimensions may very easily be bent into the required form without any hammering whatever; and I have found that small electro-magnets made in this way display the magnetic powers in a very exalted degree."

brought into play, are qualifications admirably adapted for their introduction into a variety of arrangements in which powerful magnets so essentially operate, and perform a distinguished part in the production of electro-magnetic rotations; whilst the versatilities of polarity of which they are susceptible are eminently calculated to give a pleasing diversity in the exhibition of that highly interesting class of phenomena, and lead to the production of others inimitable by any other means." [1]

Sturgeon's further work during the next three years is best described in his own words:—

"It does not appear that any very extensive experiments were attempted to improve the lifting-power of electro-magnets from the time that my experiments were published in the 'Transactions of the Society of Arts, etc.,' for 1825, till the latter part of 1828. Mr. Watkins, philosophical-instrument maker, Charing Cross, had, however, made them of much larger size than any which I had employed, but I am not aware to what extent he pursued the experiment.

"In the year 1828, Professor Moll of Utrecht, being on a visit to London, purchased of Mr. Watkins an electro-magnet weighing about 5 pounds,—at that time, I believe, the largest which had been made. It was of round iron, about one inch in diameter, and furnished with a single copper wire twisted round it eighty-three times. When this magnet was excited by a large galvanic surface, it supported about 75 pounds. Professor Moll afterwards prepared another electro-magnet, which, when bent, was $12\frac{1}{2}$ inches high, $2\frac{1}{2}$ inches in diameter, and weighed about 26 pounds, prepared like the former with a single spiral conducting wire. With an acting galvanic surface of 11 square feet, this magnet would support 154 pounds, but would not lift an anvil which weighed 200 pounds.

"The largest electro-magnet which I have yet [1832] exhibited in my lectures weighs about 16 pounds. It is formed of a small bar of soft iron, $1\frac{1}{2}$ inches across each side. The cross-piece, which joins the poles, is from the same rod of iron, and about $3\frac{3}{4}$ inches long. Twenty separate strands of copper wire, each strand about 50 feet in length, are coiled round the iron, one above another, from pole to pole, and separated from each other by intervening cases of silk. The first coil is only the thickness of one ply of silk from the iron; the twentieth, or outermost, about half an inch from it. By this mean the wires are completely insulated from each other without the trouble of covering them with thread or varnish. The ends of wire project about 2 feet for the convenience of connection. With one of my small cylindrical batteries, exposing about 150 square inches of total surface, this electro magnet supports 400 pounds. I have tried it with a larger battery, but its energies do not seem to be so materially exalted as might have been expected by increasing the extent of galvanic surface. Much depends upon a proper acid solution. Good nitric or nitrous acid, with about six or eight times its quantity of water, answers very well. With a new battery of the above dimensions and a strong solution of salt and water, at a temperature of 190° F., the electro magnet supported between 70 and 80 pounds when the first seventeen coils only were in the circuit. With the three exterior coils alone in the circuit, it would just support the lifter, or cross-piece. When the temperature of the solution was between 40° and 50°, the magnetic force excited was comparatively very feeble. With the innermost coil alone and a strong acid solution, this electro-magnet supports about 100 pounds; with the four outermost wires, about 250 pounds. It improves in power with every additional coil until about the twelfth, but not perceptibly any further: therefore the remaining eight coils appear to be useless, although the last three, independently of the innermost seventeen, and at the distance of half an inch from the iron, produce in it a lifting-power of 75 pounds.

"Mr. Marsh has fitted up a bar of iron much larger than mine, with a similar distribution of the conducting wires to that devised and so successfully employed by Professor Henry. Mr. Marsh's electro-magnet will support about 560 pounds when excited by a galvanic battery similar to mine. These two, I believe, are the most powerful electro-magnets yet produced in this country.

"A small electro-magnet, which I also employ on the lecture-table, and the manner of its suspension, are represented by Fig. 4. The magnet is of cylindric rod-iron, and weighs 4 ounces. Its poles are about a quarter of an inch asunder. It is furnished with six coils of wire in the same manner as the large electro-magnet before described, and will support upwards of 50 pounds.

"I find a triangular gin very convenient for the suspension of the magnet in these experiments. A stage of thin board, supporting two wooden dishes, is fastened at a proper height to two of the legs of the gin. Mercury is placed in these vessels, and the dependent amalgamated extremities of the conducting wires dip into it,—one into each portion.

"The vessels are sufficiently wide to admit of considerable motion of the wires in the mercury without interrupting the contact, which is sometimes occasioned by the swinging of the magnet and attached weight. The circuit is completed by other wires, which connect the battery with these two portions of mercury. When the weight is supported as in the figure, if an interruption be made by removing either of the connecting wires, the weight instantaneously drops on the table. The large magnet I suspend in the same way on a larger gin. The weights which it supports are placed one after another on a square board, suspended by means of a cord at each corner from a hook in the cross-piece, which joins the poles of the magnet.

"With a new battery, and a solution of salt and water, at a temperature of 190° F., the small electro-magnet (Fig. 3) supports 16 pounds."

In 1840, after Sturgeon had removed to Manchester, where he assumed the management of the "Victoria Gallery of Practical Science," he continued his work, and in the seventh memoir in his series of researches he wrote as follows:—

"The electro-magnet belonging to this institution is made of a cylindrical bar of soft iron, bent into the form of a horseshoe magnet, having the two branches parallel to each other, and at the distance of $4\frac{1}{2}$ inches. The diameter of the iron is $2\frac{3}{4}$ inches: it is 18 inches long when bent. It is surrounded by fourteen coils of copper wire,—seven on each branch. The wire which constitutes the coils is one-twelfth of an inch in diameter, and in each coil there are about seventy feet of wire. They are united in the usual way with branch wires, for the purpose of conducting the currents from the

[1] Sturgeon's Scientific Researches, p. 113.

battery. The magnet was made by Mr. Nesbit. . . . The greatest weight sustained by the magnet in these experiments is $12\frac{3}{4}$ hundredweight, or 1,386 pounds, which was accomplished by sixteen pairs of plates, in four groups of four pairs in series each. The lifting-power by nineteen pairs in series was considerably less than by ten pairs in series, and but very little greater than that given by one cell or one pair only. This is somewhat remarkable, and shows how easily we may be led to waste the magnetic powers of batteries by an injudicious arrangement of its elements."[1]

At the date of Sturgeon's work the laws governing the flow of electric currents in wires were still obscure. Ohm's epoch-making enunciation of the law of the electric circuit appeared in "Poggendorf's Annalen" in the very year of Sturgeon's discovery, 1825; though his complete book appeared only in 1827, and his work, translated by Dr. Francis into English, only appeared (in Taylor's "Scientific Memoirs," vol. ii.) in 1841. Without the guidance of Ohm's law, it was not strange that even the most able experimenters should not understand the relations between battery and circuit which would give them the best effects. These had to be found by the painful method of trial and failure. Preeminent among those who tried was Professor Joseph Henry, then of the Albany Institute in New York, later of Princeton, N.J., who succeeded in effecting an important improvement. In 1828, led on by a study of the "multiplier" (or galvanometer), he proposed to apply to electro-magnetic apparatus the device of winding them with a spiral coil of wire "closely turned on itself," the wire being of copper from one-fortieth to one-twenty-fifth of an inch in diameter, covered with silk. In 1831 he thus describes[2] the results of his experiments:—

"A round piece of iron about a quarter of an inch in diameter was bent into the usual form of a horseshoe; and instead of loosely coiling around it a few feet of wire, as is usually described, it was tightly wound with 35 feet of wire covered with silk, so as to form about 400 turns. A pair of small galvanic plates, which could be dipped into a tumbler of diluted acid, was soldered to the ends of the wire, and the whole mounted on a stand. With these small plates, the horseshoe became much more powerfully magnetic than another of the same size and wound in the same manner, by the application of a battery composed of 28 plates of copper and zinc, each 8 inches square. Another convenient form of this apparatus was contrived by winding a straight bar of iron, 9 inches long, with 35 feet of wire, and supporting it horizontally on a small cup of copper containing a cylinder of zinc. When this cup, which served the double purpose of a stand and the galvanic element, was filled with dilute acid, the bar became a portable electro-magnet. These articles were exhibited to the institute in March, 1829. The idea afterwards occurred to me that a sufficient quantity of galvanism was furnished by the two small plates to develop, by means of the coil, a much greater magnetic power in a larger piece of iron. To test this, a cylindrical bar of iron, half an inch in diameter, and about 10 inches long, was bent into the shape of a horseshoe, and wound with 30 feet of wire. With a pair of plates containing only $2\frac{1}{2}$ square inches of zinc, it lifted 15 pounds avoirdupois. At the same time a very material improvement in the formation of the coil suggested itself to me on reading a more detailed account of Professor Schweigger's galvanometer, which was also tested with complete success upon the same horseshoe. It consisted in using several strands of wire, each covered with silk, instead of one. Agreeably to this construction, a second wire, of the same length as the first, was wound over it, and the ends soldered to the zinc and copper in such a manner that the galvanic current might circulate in the same direction in both; or, in other words, that the two wires might act as one. The effect by this addition was doubled, as the horseshoe, with the same plates before used, now supported 28 pounds.

"With a pair of plates 4 inches by 6 inches, it lifted 39 pounds, or more than fifty times its own weight.

"These experiments conclusively proved that a great development of magnetism could be effected by a very small galvanic element, and also that the power of the coil was materially increased by multiplying the number of wires without increasing the number of each."[1]

[1] Sturgeon's Scientific Researches, p. 188.

[2] Silliman's American Journal of Science, January, 1831, xix. p. 400.

[1] Scientific Writings of Joseph Henry, p. 39.

NOTES AND NEWS.

THE well known writer on vegetable paleontology, Professor E. Weiss of Berlin, died on July 5 last.

— The annual meeting of the American Folk-Lore Society will be held Nov. 28 and 29, 1890, at Columbia College, New York. A preliminary meeting for the purpose of organizing a local committee of arrangements was held at Room 15, Hamilton Hall, Columbia College, 49th Street and Madison Avenue, on Wednesday, Oct. 8, at 4 P.M

—We learn from the *Medical and Surgical Reporter* of Oct. 4 that there were registered in the second trimester 908 foreigners who were studying medicine in France, of whom 822 were in Paris. Of the latter there were, from Russia, 261; the United States, 159; Roumania, 85; Turkey, 71; England, 51; Spain, 34; Greece, 34; Switzerland, 25; Servia, 20; Portugal, 18; Egypt, 13; Italy, 12; Bulgaria, 8; Austria, 7; Belgium, 7; and Holland, 60.

— By the death of Professor Carnelley the science of chemistry in England has suffered an irreparable loss. It appears, as we learn from *Nature*, that some little time ago Dr. Carnelley had been suffering from an attack of influenza, and it was while returning to Aberdeen after a journey to the south, made with the object of recruiting his health, that he was seized with sudden and severe illness, which was due, as his medical attendants discovered, to the formation of an internal abscess. Surgical aid proved unavailing, the patient's strength gradually gave way, and Dr. Carnelley passed away at mid-day of Aug. 27, at the comparatively early age of thirty-eight.

—The report of Dr. Eitel, inspector of schools in Hong Kong, for the past year, contains some interesting details. According to *Nature*, the total number of educational institutions of all descriptions, known to have been at work in the colony of Hong Kong during the year 1889, amounts to 211 schools, with a grand total of 9,681 scholars under instruction. More than three fourths of the whole number of scholars, viz., 7,659, attended schools (106 in number) subject to government supervision, and either established or aided by the government. The remainder, with 2,022 scholars, are private institutions, entirely independent of government supervision, and receiving no aid from public funds. The total number of schools subject to direct supervision and annual examination by the inspector of schools amounted, in 1389, to 104, as compared with 50 in 1879, and 19 in 1869. The total number of scholars enrolled in this same class of schools during 1889 amounted to 7,107, as compared with 3,460 in 1879, and 942 in 1869: in other words, there has been an increase of 31 schools and 2,518 scholars during the ten years from 1869 to 1879, and an in-

crease of 54 schools and 3,647 scholars during the ten years from 1879 to 1889. It would seem, therefore, that the decennial increase of schools and scholars during the last twenty years has shown a tendency to keep up with the progressive increase of population. Comparing the statistics of individual years, the number of schools under supervision and examination by the inspector of schools rose from 94 in 1887. and 97 in 1888, to 104 in 1889, while the number of scholars under instruction in these same schools rose from 5,974 in 1887, and 6,258 in 1888, to 7,107 in 1889. There is, therefore, a steady annual increase during the last three years, progressing from an increase of 284 scholars in 1888 to an increase of 849 in 1889. The expenses incurred by the government during the year 1889, on account of education in general, amounted, exclusive of the cost of new school-buildings, to a total of $53,901.

—Mr. E. Nevill, the government chemist at Natal, in his last report to the colonial secretary, notes that valuable deposits of argentiferous galeno of copper and of bismuth exist in the colony, and of such rich nature that they could be profitably exported in bulk. In both Alexandra and Umvoti Counties, as stated in *Nature* of Sept. 25, deposits of silver-bearing lead ore have been found containing from ten to fifteen pounds' worth of silver per ton of lead ore. Saltpetre has been found so rich as to be worth more than three times as much as the best Peruvian deposits. Plumbago, asbestos, and the mineral phosphates appear to be of inferior quality. Several calcareous formations have been examined, which are likely, under proper treatment, to yield good hydraulic cement.

—Some chemical re-actions can be started or accelerated by sunlight, and an increased effect is to be expected where the rays are concentrated by a lens or concave mirror. Herr Brühl has described experiments made in this way, in production of zinc ethyl from zinc and ethyl iodide,—a re action difficult to start. As given in *Nature*, the retort, containing zinc filings and several hundred grams of ethyl iodide, was placed at the focus of a concave mirror, about a foot in diameter, receiving the sun's rays. The re-action soon began, and grew so vigorous that cooling was necessary. In a quarter of an hour all the ethyl iodide was conconsumed, and, through the subsequent distillation in an oil-bath, a good yield of zinc ethyl was had. This radiation process, it is suggested, might be variously useful in actions on halogen-compounds, which tend to be disaggregated by sunlight A lens, owing to the athermanous property of glass, wguld be less powerful.

—Lord Rayleigh has recently had under observation, says *Engineering* of Sept. 26, some cases of defective color-vision which prove, what seems only natural, that we cannot simply distinguish trichromic and dichromic color-vision, as has sometimes been done. Normal color-vision is trichromic; color-blind people have dichromic vision. If we have black, white, blue, red, green, we can match two against three. For dichromic vision we want only four colors; for instance, those mentioned without white. For ordinary purposes the wool test will suffice: if not, we recur to spinning disks,—two concentric disks, the one over the other, the inner one consisting of sectors of different colors, the outer one showing ring portions. The disks are made of colored cardboard, and have a radial slit, so that we can make up any combination we like; e.g., 10 parts of black + 45 white + 35 green, 100 making the total circumference. Sometimes patients prove obstinate, and will not say when they consider the inner and outer disk matches. Such are examined by means of an older apparatus of Lord Rayleigh's, a color-box with a revolving Nicol. Here they often commit themselves, and discover differences of brightness only, where there are evident differences of color. As an example of a peculiar match, Lord Rayleigh gave the following: 64 green + 36 blue = 61 black + 39 white, that is, a green-blue against a gray; another, 82 red + 18 blue (crimson) = 22 green + 78 blue. But such people are not always consistent in their way: they will make certain matches, but refuse to acknowledge others which appear suited for them. One case, for instance, first thought to be dichromic, finally proved not to be so; the sensibility for red not being altogether absent, but only impaired. Such cases have been little studied as yet. Lord Rayleigh further referred at the meeting of the British Association, at which his paper was delivered, to Maxwell's color-triangle, and the position of the black and the dark spot.

—The last two numbers of *Cosmos* contain some very interesting information on various topics. Some new discoveries have been made at Pompeii, near the Stabiana Gate, and a description is given of them. *Nature* states that three bodies were found, two being those of men, and the third that of a woman. Not far from the resting-place of these bodies was found the trunk of a tree, 3 metres in height, and measuring 40 centimetres in diameter. This tree, together with its fruits that were found with it, have been examined by the professor of botany, M. Pasquale, who finds in it a variety of *Laurus nobilis*. By means of the fruits, since they come to maturity in the autumn, he concludes that the eruption did not take place in August, but in November.

—It was observed a short time ago by Dr. Kremser, says *Nature* of Sept. 25, that the curve of mortality in North Germany lagged about two months behind that of the variability of temperature. An inquiry into this matter in the case of Budapesth has been lately made by Dr. Hegyfoky, taking the nine years 1873–81. Comparing the months, he failed to make out a certain connection; but taking into account other meteorological elements besides temperature, and reckoning by seasons, he found the variability of weather in the different seasons to give the following order from maximum to minimum: winter, spring, autumn, summer. As regards mortality, the order was spring, summer, winter, autumn. Thus it appears there is a displacement of three months. If a connection of the kind referred to really exists between weather and mortality, the effect (mortality) must appear somewhat later than the cause (variation of weather).

—We learn from *Engineering* of Sept. 26 that the Forth Bridge has been for some time entirely completed, the works have been dismantled, and the engineers' staff and the workmen have had to seek new fields of operation, some of the engineers having gone to Mexico, America, Greece, and India. The finishing touch, it is interesting to note, is the only thing in the way of ornament on the bridge, all else being indispensable parts of the structure. This embellishment consists of two brass plates placed on the south cantilever pier, in commemoration of the opening of the bridge by the Prince of Wales on March 4, 1890. The names of the directors, engineers, and contractors are also given. Sir John Fowler has had fitted at the end of the south main span, at which point the contraction and expansion joint is placed, an indicator to record the number of trains passing and the daily contraction or expansion of the bridge. The apparatus consists of a brass rod, with a pencil, attached to the end of the girder, and a clock with another brass rod fixed in its axle. Round the rod in the axle of the clock is wound a strip of paper about four inches wide, with a weight attached to the end. The point of the pencil rests on this paper, which is, of course, constantly on the move as the clock winds down. The result is, that as the cantilever contracts, the pencil attached to it is pulled away; when it expands, the pencil is pushed forward; and a curve of contraction and expansion is thus produced by the movement of paper and pencil combined. The same principle is applied to register the behavior of the bridge while a train is passing. When the train enters on the one end of the cantilever, it pulls the far-off end down; and when it does so, it also pulls the pencil, and thus a mark at right angles to the curve of contraction and expansion is made. When it passes to the other half of the cantilever, it pushes it forward, and again a mark at right angles to the curve is made on the other side. Each mark indicates a train, and thus the simple apparatus serves three purposes. The management are troubled a good deal with requests for passes to inspect the bridge; but as walking over the bridge, owing to the narrowness of the sidewalk, is attended with considerable danger, very few are granted. The speed of the trains in crossing the bridge is not now limited, except in the case of goods trains, and with them it must not exceed twenty-five miles an hour. As there are only about two feet six inches between the pedestrian on the bridge and the flying train, it is seen that the precaution is wise. The average traffic on the bridge amounts to about one hundred and forty trains daily.

SCIENCE:

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Attention is called to the "Wants" column. All are invited to use it in soliciting information or seeking new positions. The name and address of applicants should be given in full, so that answers will go direct to them. The "Exchange" column is likewise open.

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AN IMPORTANT MEETING OF MINING AND METALLURGICAL ENGINEERS.

A JOINT meeting of the American Institute of Mining Engineers, the Iron and Steel Institute of Great Britain, and the Verein Deutscher Eisenhuettenleute of Germany, was held in this city last week. The meeting of the American Institute of Mining Engineers occupied the first two days, the sessions being held in Chickering Hall. At the first session, on Monday afternoon, addresses of welcome were delivered by J. F. Lewis and Hon. Abram S. Hewitt. Then, after some routine business, the reading of papers began, the first being on "Explosions from Unknown Causes," by J. C. Bayles. Five other papers, by John C. Fowler, F. H. McDowell, Clemens Jones, C. M. Ball, and Oberlin Smith, were read by title.

At the Monday evening session papers were read by W. B. Potter and W. F. Durfee.

The first paper of the Tuesday morning session, by H. H. Campbell, was read by title and not discussed. In the next paper, by H. C. Spaulding, which treated of electric power-transmission in mining operations, and in the discussion of it, the advantages of the alternating current for the distribution of power over long distances were clearly set forth. The other papers at this session were read only by title.

On Tuesday afternoon only two papers were read and discussed; namely, "Recent Improvements in German Steel-Works and Rolling-Mills," by R. M. Daelen, and "Machinery for Charging and Heating Melting-Furnaces," by S. T. Wellman. Several other papers were read by title.

At the Tuesday evening session Alphonse Fteley read a paper on "The Water-Supply of New York City." The concluding papers of the session were by James Douglas, jun., and Eckley B. Coxe.

On Wednesday morning the Iron and Steel Institute began its meeting, President Sir James Kitson in the chair. Andrew Carnegie, chairman of the reception committee, delivered the address of welcome, which was responded to by the president, who then read his formal presidential address. The usual routine business of the institute was then disposed of. Technical papers were read by James Gayley and E. S. Cook. In the afternoon all who desired went on an excursion up the Hudson.

On Thursday the Bessemer gold medal and diploma were formally presented to Hon. Abram S. Hewitt. In the afternoon James Dredge, editor of *Engineering*, delivered an address on the late Alexander Lyman Holley, after which the audience went in a body to Washington Square, where a statue of Holley was unveiled. The evening was devoted to banquets and receptions.

On Friday visits were made to points of interest in and about the city, and on Saturday the visitors departed for Philadelphia.

WHEAT SMUT.

BULLETIN No. 12 of the Experiment Station of the Kansas State Agricultural College, Manhattan, Kan., is on some "Preliminary Experiments with Fungicides for Stinking-Smut of Wheat." In very many localities, in nearly every wheat-growing country, the crop is more or less injured, and sometimes seriously damaged, by a disease called "stinking-smut," "bunt," or simply "smut." This disease is not detected until the plants have headed out, and even then it is often overlooked. Before the grain ripens, a careful examination reveals the fact that certain heads have a dark, bluish-green color, while healthy plants present a lighter, yellowish-green color. During and after ripening of the grain, the smutted heads have a paler appearance than healthy ones. At no time do the smutted heads present the yellowish shade so characteristic of ripening wheat. When the smutted heads are examined, it is found that the grains have become dark and more or less swollen. They are at first of a greenish color, but become brownish or grayish when fully ripened. Because of their being usually swollen, the smutted grains push the chaff apart more than the sound kernels do, giving the head a slightly inflated and somewhat abnormal appearance. If one of the swollen smutted grains be crushed, it is found to be filled with a rather dull-brownish powder, which has a very disagreeable and penetrating odor. Often the disease is not discovered till the grain is threshed, when it is recognized by the odor arising from the smutted grains crushed by the machine. The smut may also be recognized during the milling, both from the odor arising during the grinding and by the dark streaks found in the flour. The dissemination of the disease is brought about by the use of smutted seed. The brown powder (smut) lodged in the threshing-machine may infect the seed, or the smut remaining in the field may, perhaps, through the soil, infect the succeeding crop. A summary of the results of the experiments at the Kansas Station, which were carried out by the botanists W. A. Kellerman and W. T. Swingle, shows that the stinking-smut of wheat is a destructive disease, caused by two closely allied, parasitic fungi called *Tilletia fœtens* and *Tilletia Tritici*; that these two species of smut differ only in a few microscopic characters, and both produce the same disease; that the disease is spread by spores of these fungi adhering to the sound grains before they are planted, or perhaps rarely by spores present in the soil; that the damage from this disease is often very considerable, sometimes amounting to from one-half to three-quarters of the whole crop; that in ordinary cases the disease can be entirely prevented by soaking the seed fifteen minutes in water heated to 132° F.; that the other fungicides used, when decreasing the amount of smut, at the same time also interfered with the germination, and reduced the vigor of the plants; and that seed from clean fields (if the adjoining fields were not smutty) will produce a crop of wheat free from smut.

HEALTH MATTERS.

The Diaphanous Test of Death.

DR. BENJAMIN WARD RICHARDSON, in the last *Asclepiad*, speaks of a paragraph making the round of the scientific and general press which must be accepted *cum grano*. In this paragraph, according to the *Boston Medical and Surgical Journal*, it is stated that the French Academy of Sciences ten or fifteen years ago offered a prize of $8,000 for the discovery of some means by which even the inexperienced might at once determine whether in a given case death had or had not ensued. A physician obtained the prize. He had discovered the following well-known phenomenon. If the hand of the suspected dead person be held towards a candle or other artificial light with the fingers extended and one touching the other, and one looks through the spaces between the fingers towards the light, there appears a scarlet red color where the fingers touch each other, due to the blood still circulating, and showing itself through the tissues, if life have not yet ceased. When life is entirely extinct, the phenomenon of scarlet space between the fingers at once ceases. The most thorough trials, it was said, had established the truth of this observation.

Dr. Richardson says that in his essay on absolute proofs of death he has described this test with the others, and has attached to it its true value. The statement that the test is sufficient of itself is, however, too solemn to be allowed to go without correction; and he therefore affirms, with all possible earnestness, that the test, trusted to alone, is capable of producing the most serious error. In the case of a person in a state of syncope, where the test was most carefully applied, there was not the faintest trace of red coloration between the fingers; yet recovery from the syncope was quite satisfactory without any artificial aid. The test is one which admits of being readily tried, and, *prima facie*, it is a good test to bring into operation. But as an absolute proof of death Dr. Richardson would put before it, (1) the pulsation of the heart, (2) the respiratory murmur, (3) pressure on veins, (4) the electric test for muscular irritability, (5) the ammonia hypodermic test, (6) coagulation of blood in the veins, (7) rigor mortis, and (8) decomposition.

Impurities under Finger-Nails.

The progress of bacteriology has shown that aseptic surgery means scientific cleanliness. The same lines of investigation show how very dirty people can be. Seventy-eight examinations of the impurities under finger-nails were made in the bacteriological laboratories of Vienna, and the cultivations thus produced showed thirty-six kinds of micrococci, eighteen bacilli, three sarcinæ, and various varieties. The spores of common mould were very frequently present. The removal of all such impurities is an absolute duty in all who come near a wound. It is not enough to apply some antiseptic material to the surface of dirt: the impurity must be removed first, the hand antisepticized after. Some physicians, when intending to drain dropsical legs by acupuncture or other methods, are very careful to use antiseptic dressings, and in such cases have the feet and toe-nails purified and rendered aseptic as far as possible. It is sometimes said that the scratch of a nail is poisonous. There is no reason to suspect the nail-tissue: it is more likely the germs laid in a wound from a bacterial nest under the nail. Children are very apt to neglect to purify their nails when washing hands; and this matter is not always sufficiently attended to among surgical patients. Personal cleanliness is a part of civic duty, and, as Dr. Abbott well expressed the matter in his address to teachers, should be taught to school-children, and insisted on in practice. The facts we have recorded might well form the text for a school homily, especially when any epidemic was in the neighborhood.

Some Cases of Prolonged Want of Food.

A correspondent of *The Lancet* writes as follows on this subject: "The name of Gen. Colletta, author of the 'History of the Kingdom of Naples from 1734 to 1825,' is one of the most respected in the annals of modern Italy, and his reputation for discernment and veracity may fairly be placed on a level with that of the Duke of Wellington in our own country. His description of the terrible earthquake which in 1783 devastated Calabria, and was severely felt throughout the Kingdom of the Two Sicilies, is of unquestioned authority, and from it the following incidents are extracted. They refer only to persons and animals imprisoned beneath the ruins caused by the earthquake. It is only necessary to add that the facts were ascertained by Gen. Colletta's personal investigations at the scene of the catastrophe. 1. A female child, eleven years of age, was extricated on the sixth day and lived; and another girl, sixteen years of age, Eloisa Basili, remained under ground for eleven days, holding in her arms an infant which had died on the fourth day, so that it was decomposed and putrefied at the time of her rescue. She was unable to free herself from the shocking burden in her arms, so closely were they hemmed in by the fallen wreckage. 2. More wonderful still, as regards duration of life, were certain cases that occurred among animals. Two she-mules existed under a heap of ruins, the one twenty-two days, the other twenty-three; a fowl lived for twenty-two days; and a pair of hogs, which were completely entombed, remained alive thirty-two days. The human beings who had undergone these unwonted privations, when interrogated as to their sensations, replied, 'I can recollect only up to a certain point, and then I fell asleep.' When it is remembered that all the creatures thus circumstanced were deprived entirely of water or other liquids, it is hardly to be wondered at, that, though there was no desire for solid food, they displayed on their liberation an insatiable thirst, and, the author adds, partial blindness,—*sete inestinguibile e quasi cecità*."

Long-Immersed Human Subjecst.

A very interesting report has just been issued by Dr. König of Hermannstadt, on the state in which the human subject, after forty years' immersion in water, may be found by the physiologist. In the revolutionary upheaval of 1849, a company of Honvéds, as the Hungarian militia are called, having fallen in the vicissitudes of war, were consigned to the waters of the Echoschacht, a pool of considerable depth not far from Hermannstadt. Their bodies, as we learn from the *Lancet* of Aug. 9, 1890, have recently been brought up to the light of day, and subjected to a careful and minute investigation from the physiologist's point of view. Dr. König found them in perfect preservation, without a single trace of any decomposing process. Externally they had the appearance of having been kept in spirit. The epidermis was of a whitish-gray color; the muscles, rose-red, feeling to the touch like freshly slaughtered butcher's meat. The lungs, heart, liver, spleen, kidneys, bladder, stomach, and alimentary canal were of the consistence of those in a newly deceased corpse; while the brain was hard and of a dirty-gray color, as if preserved in spirit. Structurally the organs retained their outline perfectly, and were so easily recognizable in tissue as well as configuration, that, according to Dr. König, they might have been exhibited for "demonstration" in an anatomical lecture-room. After forty-one years under water, these are indeed remarkable phenomena. The large intestine contained fæces of a yellowish-brown color, quite unaltered and inodorous; while the bladder was partially filled with straw-colored urine. But perhaps the most significant feature disclosed by these corpses is the following: in their interior a large amount of chloride of sodium, crystallized in cubes, had been deposited and fixed on the several tissues and organs, and this salt had not penetrated mechanically into the dead bodies from without. In the completely closed and perfectly unimpaired pericardium, and also on the outer surface of the heart itself, crystals of the same kind were found. This, according to Dr. König, clearly shows, that, in the water, particles held in solution may pass through the skin and the muscles, and find their way into the most deeply seated organs. Herein, he adds, we have confirmatory proof, if such were needed, that the specific virtues of mineral baths exercise in this way their salutary effect on the internal economy of the bather. There is a notable difference, however, between the time spent in the bath by an ordinary bather at a "Curort" and the forty-one years during which the Honvéds remained under water. The phenomenal quietness of the Echoschacht may also have been a material factor in this impregnation

of the corpses with chloride of sodium. But, with every allowance for such considerations, Dr. König has furnished a striking illustration of the permeability of the immersed human subject to salts in solution, and it is to be hoped that his painstaking researches will lead to others in the same important direction.

Medical Students Abroad.

Human beings are so much like sheep in their habit of following where their predecessors have led, says *Medical News* of Aug. 30, 1890, that it seems almost useless to attempt to divert their course from the clinics of Vienna or Berlin to those of London, Liverpool, or Edinburgh. Yet any one who has studied both on the continent of Europe and in England must have been impressed with a number of advantages possessed by English study over those offered in still more foreign lands. The advantage of the mother-tongue is inestimable. Very few Americans who do not possess German blood know enough of the German language to understand the terms used by a rapid lecturer in the Fatherland; and, if they do not, they lose that which they chiefly desire, namely, the minute points of the subject before them. The average American going to one of the continental clinics receives most of his instruction from docents, or other instructors of a comparatively low grade, simply because he is one of hundreds who not only throng around the chief, but overflow to the subordinates; while in England, notably in London, the number of eminent men is so great, and the percentage of foreign students so small, that each and every one can sit at the feet of the teacher whose writings are known everywhere in the civilized world. While the student in Berlin or Vienna becomes imbued with the views of the single individual governing a given course, in London he may go from hospital to hospital and obtain different views, and in consequence become a man of broader ideas and greater resource.

LETTERS TO THE EDITOR.

**** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The editor will be glad to publish any queries consonant with the character of the journal.

On request, twenty copies of the number containing his communication will be furnished free to any correspondent.

On the Minerals contained in a Kiowa County (Kansas) Meteorite.

A REMARKABLE group of meteorites has been discovered during the past year in Kiowa County, Kan. In March last a small fragment was identified by the author as being of meteoric origin, and steps were taken by Dr. F. H. Snow of the Kansas State University, Professor F. W. Cragin of Washburn College, and others, to obtain some of these masses.

The history of this find has been described by Dr. Snow (*Science*, May 9, 1890) and by George F. Kunz (*Science*, June 13, 1890). The latter writer, to whom a large number of the specimens of this fall belong, describes some very carefully, and gives some analyses of the minerals contained. In *Science*, July 18, 1890, another specimen, more recently found at this locality, is described. This as well as others noticed belongs to the class known as "pallasites." Its weight is two hundred and eighteen pounds and a quarter.

It is an irregular triangular pyramid about twenty-two inches in height, with a maximum width of seventeen inches. As it was well buried in the mud, one side of it presents numerous cavities in which are crystals that have not been destroyed by handling or by the action of the elements. One of these cavities is four inches in diameter and two inches deep. Nearly all these cavities are filled with more or less perfect crystals of light-yellow olivine and chromite.

The general color of the meteorite is a mottled reddish black, but it is redder than other specimens of this group that we have seen.

The specific gravity of the whole mass was 4.79, showing that there is not as much iron as in some of the specimens reported. A dirty-white incrustation was noticed at several places on the surface. This proved to be calcium carbonate, and is no doubt due to a deposit from the calcareous soil in which the mass was buried. A polished section shows the usual Widmannstattian figures after treatment with nitric acid.

Some quite perfect crystals of yellow olivine were secured. There is much more of an almost black variety of this mineral. Of the latter no analysis was made, as it did not seem possible to secure a uniform sample. It is suggested by Mr. Kunz that this zone is a mixture of olivine and troilite. The yellow olivine has a fusibility of 5+, blackens before the blowpipe, is attracted by the magnet after ignition but not before, gives the usual iron reaction with the borax bead, and is soluble in nitric acid with separation of gelatinous silica. It has conchoidal fracture and vitreous lustre. The analysis is as follows: —

SiO_2	38 38
FeO	13.55
MgO	46.21
MnO	.29
Cr_2O_3	.61
S	a trace
Loss on ignition	.82
	99.86

The chromite, which is found in crystals and masses lining the cavities above mentioned, is iron-black in color, with a brilliant lustre. It is brittle, gives a brown streak, and is slightly magnetic after ignition. It gives the usual emerald-green bead with borax. It is not acted upon by acids. Some of the masses are one third of an inch in diameter. In most of these cavities there are about equal quantities of olivine and of chromite. The analysis is as follows:—

SiO_2	1.42
CaO	0.78
MgO	6.11
FeO	23.21
Al_2O_3	0.25
MnO	a trace
Cr_2O_3	67.83
Loss on ignition	.24
	99.84

The iron-nickel alloy, as shown on a polished surface, is intimately associated with the troilite. Its specific gravity is 7.70. It has the following composition:—

Iron	88.08
Nickel	11.04
Cobalt	.56
Sulphur	.10
Phosphorus	.11
Silicon (?)	.05
Copper	a trace
	99.94

A specimen of troilite from the 54.96 pound meteorite of this group was also examined in our laboratory. It could not be picked clean from iron and olivine. After excluding silica and magnesia of the olivine, the composition corresponded quite closely with the analyses of troilite as reported in Dana's "Mineralogy."

This specimen is remarkable on account of the size of the depressions on its surface, and the fact that these depressions contain such pure crystals and masses of both olivine and chromite. In the interior the olivine occurs in rounded grains, filling the cavities of the iron. E. H. S. BAILEY.

Lawrence, Kan., Aug. 15.

The Unit Measure of Time.

ON the question of a name for the time-unit, referred to in an article by Dr. Sandford Fleming of Ottawa, in *Science* of Sept. 26, I see nothing better for what he wants named than "mean solar day." No suitable word of classical derivation occurs to me after thinking of the matter; and I find "mean solar day" as little objectionable as "tropical" or "sidereal," etc., "year." The best time-unit would probably be a pendulum-oscillation (of a given length) vibrating *in vacuo* at the pole of the earth.

C: MACDONALD.

Dalhousie College, Halifax, N.S., Oct. 1.

BOOK-REVIEWS.

Elliptic Functions. By ARTHUR L. BAKER. New York, Wiley. 8°. $1.50.

THOSE who want to take up this somewhat complicated subject, and who have been repelled by the larger works of foreign writers, will be glad to get hold of Professor Baker's work, who is, by the way, the professor of mathematics in the Stevens School of the Stevens Institute of Technology, Hoboken, N.J., and who was formerly connected with the scientific department of Lafayette College, Easton, Penn.

Professor Baker does not pretend to have contributed any thing to the methods of treatment, but he has aimed at smoothing the road to this increasingly important branch of mathematics, and of putting within reach of the English student a tolerably complete outline of the subject, clothed in simple mathematical language and methods.

The Principles of Psychology. By WILLIAM JAMES. 2 vols. (American Science Series, Advance Course.) New York, Holt. 8°.

IN the presence of two large and weighty volumes, embodying the slowly matured thoughts of an able and original thinker upon a subject teeming with new and fascinating problems but no less so with difficulties and pitfalls, the reviewer finds his task no ordinary one. He feels that he has before him a work destined to have considerable influence upon the progress of psychological science amongst us, and especially so because it appears at a time in the growth of the science which is particularly responsive to formative influences, and because it appeals to the advanced student, who has in some part acquired the fundamental facts, and is ready to form interpretations and opinions of his own,—a work for which the teacher of psychology will find a handy place on his book-shelf, and to which all those who in the future may attempt surveys of psychological science will make repeated and pertinent reference.

The attitude of the author to his subject is precisely that of the expert in any department of exact science to his chosen specialty. It is to psychology as a science—to scientific psychology—that Professor James contributes. "I have kept close to the point of view of natural science throughout the book. Every natural science assumes certain data uncritically, and declines to challenge the elements between which its own 'laws' obtain, and from which its own deductions are carried on. . . . This book, assuming that thoughts and feelings exist and are vehicles of knowledge, thereupon contends that Psychology, when she has ascertained the empirical correlation of the various sorts of thought or feeling with definite conditions of the brain, can go no farther—can go no farther, that is, as a natural science. If she goes farther, she becomes metaphysical." While psychology thus demands recognition as a distinct one of the sciences, it is equally desirous of keeping in intimate relationship with every other department of knowledge that can contribute to its completeness, or to which it may be useful. Especially in the present stage of rapid growth is it necessary to keep eyes and ears open to suggestions from any source, and to refrain from any narrow though ever so systematic definition of the province of psychology. Professor James's expression of this need, and defence of this position, are so admirable as to demand citation.

"The boundary-line of the mental is certainly vague. It is better not to be pedantic, but to let the science be as vague as the subject and include such phenomena as these, if by so doing we can throw any light on the main business in hand. It will ere long be seen, I trust, that we can, and that we gain much more by a broad than by a narrow conception of our subject. At a certain stage in the development of every science a degree of vagueness is what best consists with fertility. On the whole, few recent formulas have done more real service of a rough sort in psychology than the Spencerian one, that the essence of mental life and of bodily life are one, namely, 'the adjustment of inner to outer relations.' Such a formula is vagueness incarnate; but because it takes into account the fact that minds inhabit environments which act on them, and on which they in turn re-act; because, in short, it takes mind in the midst of all its concrete relations,—it is immensely more fertile than the old-fashioned 'rational psychology,' which treated the soul as a detached existent, sufficient unto itself, and assumed to consider only its nature and properties. I shall therefore feel free to make any sallies into zoölogy or into pure nerve-physiology which may seem instructive for our purposes, but otherwise shall leave those sciences to the physiologists."

While thus free to borrow from more mature sciences, psychology is not less free to develop its own methods and resources. Experimental psychology is not co extensive with scientific psychology: observation, hypothesis, comparison, and that much-abused introspection, have all equally worthy places. The mere mental fact means about as little as any other: the interpretation of it gives it life and a place in science. Such interpretation is frequently impossible except by the inner consultation of personal experience by introspection. The introspection that is dangerous, and upon which a justifiable odium has fallen, is one that soars free of experience, takes no account of the peculiarities of the mind that is "introspected," and ends by forcing the facts into accord with a fanciful theory. The introspection that Professor James so cleverly employs is one that welcomes any possible corroboration or suggestion from experiment,—one that is made necessary by the inadequacy of the facts, and has for its end the accumulation of further knowledge.

Having thus indicated the spirit and methods of the work, we may proceed to examine its scope and subject-matter. This it is difficult to describe except by enumerating the titles of chapters. It is difficult to discover the guiding principle according to which one topic is treated fully, a second sparingly, and a third entirely ignored. Indeed, one derives the impression that this guiding principle is none other than the personal interests of the author. He has gathered together the various problems of which he has at various times made special study (and in part published the results), and added thereto certain other chapters allied to these in the way of introduction or corollary. It is not, and makes no pretence of being a systematic work. The topics most liberally treated are such as the perception of space, perception of time, perception of "things," perception of reality, the stream of thought, association, attention, imagination, self-consciousness, the emotions, the will, necessary truths; though the more concrete problems of the functions of the brain, habit, discrimination and comparison, memory, instinct, hypnotism, are by no means slighted. The order of topics is also not the usual one. First are treated the complex mental operations as presented in the adult thinker; and then, as analysis shows the possibility of viewing these as elaborate instances of simpler abstract processes, the latter are more specifically studied.

The manner of treatment is everywhere attractive, and there are few dull pages in the book. There is a wealth of illustrative material gathered from a great variety of sources, and the descriptions of mental and emotional conditions are always bright and pertinent. As one instance of many, take the following description of the state of distraction, or "brown study:" "The eyes are fixed on vacancy; the sounds of the world melt into confused unity; the attention is dispersed so that the whole body is felt, as it were, at once; and the foreground of consciousness is filled, if by any thing, by a sort of solemn sense of surrender to the empty passing of time. In the dim background of our mind we know, meanwhile, what we ought to be doing: getting up, dressing ourselves, answering the person who has spoken to us, trying to make the next step in our reasoning. But somehow we cannot *start:* the *pensée de derrière la tête* fails to pierce the shell of lethargy that wraps our state about. Every moment we expect the spell to break, for we know no reason why it should continue. But it does continue, pulse after pulse, and we float with it until —also without reason that we can discover—an energy is given, something—we know not what—enables us to gather ourselves together, we wink our eyes, we shake our heads, the background-ideas become effective, and the wheels of life go round again."

Finally, with regard to the practical value of the work. What is its place as a text-book? It certainly can hope for only a limited field. It takes for granted that knowledge which it is the purpose of most college courses in psychology to convey; and,

even when such topics are treated, the discussion is begun *in medias res*, taking up the points of chief interest and referring to other works for the rest. There are few students indeed who can be counted upon to have this knowledge; and there is great danger that the student will think he has practically acquired this knowledge when he has paged through an elementary text-book of physiology, or will regard the acquisition of it as a slight and unimportant consideration. The youthful fondness for the most abstract and least soluble problems should be decidedly suppressed as regards the study of psychology; and, before such a student can at all profit by Professor James's volumes, he must have successfully outgrown this earlier stage. Then, again, the extreme eclecticism regarding the points considered would hardly be rightly interpreted by the student. The order of topics is also unpedagogical; but the author suggests in the preface a changed order, with omission of certain chapters, which would partly remedy this defect. Furthermore, the great size of the work renders it unsuitable to college purposes. There is no attempt at condensation or suppression. One feels that the writer is taking all the space that he wants, and fashioning his exposition of a topic according to his personal interest in it. One obtains very frequent glimpses of the personality of the author; and the text and footnotes, with their frequent witticisms and telling phrases, are about as unlike the ordinary text-book strain as could be imagined. It will be mainly to the teacher, and to those preparing to be teachers, that this work will appeal, and to them mainly as a reference-book for inspiring views of a few topics.

Psychology teaches that the proverbial odium attaching to comparisons is irrational, and that this is a legitimate and useful method of forming a judgment. Accordingly, it will be fitting to compare this new work with former attempts at a survey of modern psychological doctrines. It more immediately invites comparison with the works of Wundt and of Ladd. It lacks the completeness and patient collection of facts characteristic of both these works: it forms a marked contrast to them in the clearness and interest of its expositions. The student is repelled by Wundt or Ladd, but will be attracted to James. It shares in common with Wundt's work, what is perhaps the greatest defect of Ladd's, in giving the reader an impression of originality, coupled with sincere enthusiasm on the part of the author. It is less fitted than either to be the basis of a course in psychology, and is much more than these an expression of personal views and interests. This may suffice to indicate the probable sphere of the work, and to suggest to the reader how far and in what way the work may answer his needs; and we can certainly echo the sentiment expressed by the author in his preface: "But *wer Vieles bringt wird Manchem etwas bringen;* and, by judicious skipping according to their several needs, I am sure that many sorts of readers, even those who are just beginning the study of the subject, will find my book of use."

The Theory of Determinants in the Historical Order of its Development. Part I. By THOMAS MUIR. London and New York, Macmillan. 8°.

PROFESSOR MUIR'S treatise on the theory of determinants is well known, and it may interest our readers to know that a new and greatly enlarged edition of the work is in course of preparation. Part I., which is before us, is devoted especially to a history of determinants in general, from Leibnitz in 1693 to Cayley in 1841. Every one is familiar with the tendency to overrate the influence of a few great minds on the progress of any science. It is easier for the students of a science to look up the work of those with whose names they are most familiar; and from lack of confidence, they feel obliged to overlook the more obscure workers, even if they know of their existence.

In the book before us Professor Muir has attempted to round out the history of determinants by bringing forth in their true relations the contributions of all those who have taken part in the

Publications received at Editor's Office, Sept. 15–Oct. 4.

AMERICAN Household Magazine. Vol. I. No. 1. *m.* Philadelphia, Amer. Household Mag. Co. 16 p. f°. 50 cents per year.
CANADA, Proceedings of the Royal Society of, for the Year 1889. Vol. VII. Montreal, Dawson Bros. 491 p. 4°.
CÓRDOBA, Actas de la Academia Nacional de Ciencias de la República Argentina en. Tome VI. Buenos Aires, Academia Nacional. 1027 p., plates. f°.
DAUCHY & COMPANY'S Newspaper Catalogue, 1890. New York, Dauchy & Co. 623 p. 4°.
HARDY, I. Elementary Composition Exercises. New York, Holt. 169 p. 12°.
INGALLS, J. M. Handbook of Problems in Direct Fire. New York, Wiley. 389 p. 8°. $4.
JAMES, W. The Principles of Psychology. 2 vols. New York, Holt. 1394 p. 8°.
MONIST, The. Vol. I. No. 1, October, 1890. *q.* Chicago, Open Court Publ. Co. 160 p. 8°. $2 per year.
SCHURMAN, J. G. Belief in God: its Origin, Nature, and Basis. New York, Scribner. 266 p. 12°. $1.25.
SMITH, G. J. A Synopsis of English and American Literature. Boston, Ginn. 125 p. 8°. $1.20.
SMITH, J. B. Contribution toward a Monograph of the Insects of the Lepidopterous Family Noctuidæ of Temperate North America.—Revision of the Species of the Genus Agrotis. (Bull. U. S. Nat. Mus., No. 38.) Washington, Government. 237 p. 8°.
U. S. NAVY DEPARTMENT. A Year's Naval Progress. Annual of the Office of Naval Intelligence. June, 1890. Washington, Government. 423 p. 8°.
WEBSTER'S Address at the Laying of the Corner-Stone of Bunker-Hill Monument, with a Sketch of Webster's Life. Boston, Ginn. 23 p. 12°.
WIECHMANN, F. G. Sugar Analysis. New York, Wiley. 187 p. 8°. $2.50.

development of the theory, whether great or small. For many years the theory seemed to belong especially to German mathematicians; but the author believes that he has overlooked little of importance, and that he has been impartial in his treatment of the subject.

An Introduction to the Logic of Algebra. By ELLERY W. DAVIS. New York, Wiley. 8°. $1.50.

AS the author puts it, this book is precisely described by the title, and is mainly the outgrowth of a conviction that the logic of algebra is a very much neglected study. We believe it to be the conviction of many teachers of mathematics that one trouble with students in failing to understand the subject is that they look too far. Each step in mathematical reasoning is simple in itself, and the difficulty comes in in deciding what shall be the next step in any process of mathematical reasoning.

Professor Davis, who is, by the way, the professor of mathematics in the University of South Carolina, has certainly produced a unique book, and one that will be of great interest to teachers of algebra; but the question naturally occurs to one that possibly he may have made to appear complicated what heretofore has been more or less readily accepted by students. It is quite true that the processes of algebra are simple and easily taught, and that they are taught mainly for the sake of the processes rather than for the sake of the discipline,—that is, they are taught for the uses to which they may be put,—and it is to be feared that if too much attention is paid to the reasoning which underlies the processes, which has been generally slurred over or even absolutely ignored, the student may think there is more in it than there really is, and become correspondingly confused.

AMONG THE PUBLISHERS.

THOSE having young persons in their charge whom they would interest in science should write to Gustav Guttenberg, care of the Central High School, Pittsburgh, Penn. Mr. Guttenberg carries on by correspondence classes in the study of mineralogy, and has just issued the "third grade," as he calls it, of his "Course." This pamphlet is especially devoted to the determination of ores. The methods of determination by blowpipe analysis are treated of in the first part of the book; and the closing chapters are devoted to the determination of the minerals in Collection 3, so called, which contains thirty or forty specimens sent out in a neat wooden box about seven inches square by an inch and a half deep. Those older persons who are anxious to develop some hobby will also find something of interest in Mr. Guttenberg's courses.

—Joseph M. Wade, Columbia Street, Dorchester, Mass., in his prospectus of *Occultism and Theosophy*, says, "This is the name of our new magazine, which is the outgrowth of *Truths of Nature*, and practically a continuation of that magazine. With increased experience, the editorial lines will be more carefully drawn, as it is intended that the magazine shall aid the earnest seeker after nature's truths, and point the way to the attainment of a pure, spiritual life, as defined in nature's teachings. It will define theosophy proper as against organized sectarianism, and not enter the field of the spiritual and 'Theosophical' papers now published; but it will chronicle and explain, as far as possible, the higher phenomena of spiritual life. It will point the way, and give the key for the development of the spiritual man as against all illusions, and teach absolute peace under all conditions."

What the exact meaning of this may be is left to our readers to decide.

—The October number of the *New England Magazine* is first and foremost a cotton centennial number. The two principal illustrated articles are on "Pawtucket and the Slater Centennial" and "The Cotton Industry in New England." The agricultural interest, to which so much attention was paid in the last number of this magazine, receives further attention in three articles in the present number; a general article on 'Agricultural Education," by Mr. Reeve; an illustrated article on the Massachusetts Agricultural College, by President Goodell of the college; and a story entitled "John Toner's Scheme."

—The current (Oct. 4) issue of *Architecture and Building* is devoted to the study of schoolhouse architecture from both the point of view of the teacher and the architect. The issue contains twenty-one different designs by architects who have achieved distinction in designing buildings for school purposes. The number contains sixteen double-page plates.

Wants.

Any person seeking a position for which he is qualified by his scientific attainments, or any person seeking some one to fill a position of this character, be it that of a teacher of science, chemist, draughtsman, or what not, may have the 'Want' inserted under this head FREE OF COST, *if he satisfies the publisher of the suitable character of his application. Any person seeking information on any scientific question, the address of any scientific man, or who can in any way use this column for a purpose consonant with the nature of the paper, is cordially invited to do so.*

WANTED.—To purchase a complete set, or single numbers, of Loomis' contributions to meteorology, published in the *American Journal of Science.* Address communication, stating price, to FRANK WALDO, Mountain Lake Park, Garrett Co., Maryland.

COULD some one inform me what the ingredients and origin of asphalt as used for street-paving and gathered at Trinidad are? Also how gathered and shipped by natives, and mode of refining by the Warren-Scharf Co. of New York and the Barber Co. of Washington? G. KNIPER, 28 Gunn Block, Grand Rapids, Mich.

WANTED.—A position in a Normal School or College as teacher of Botany, Physiology, Zoölogy, Embryology, Chemistry, Physics, or German, by a university graduate who has done special work in the above lines. Several years' experience in teaching, and one year as assistant in Biology in a prominent university. Box 396, Greencastle, Ind.

PROFESSOR W. M. DAVIS, Harvard College, Cambridge, Mass., desires to correspond with professional and amateur photographers, from whom he can obtain views of New England landscapes.

WANTED.—Advertisements of text-books and good standard works on Natural History, for stocking a library. Add price. Address M. D. SULLIVAN, St. Louis University, St. Louis, Mo.

WANTED—Index to Vol. VIII. and a copy of No. 205 of SCIENCE. Ten cents will be paid for a copy of either of these if in good condition. Publisher of SCIENCE, 47 Lafayette Place, New York.

TO PRINCIPALS OR COMMITTEES.—Professor of Classics and Sciences, experienced in advertising and building up schools, now employed, desires change. WILLIAM, Roslyn, L. I.

WANTED.—A graduate from the Advanced Course of the Framingham State Normal School desires an assistant's position in a high school. An appointment in New England preferred. Address G., Lock Box 4, Framingham, Mass.

Exchanges.

[Free of charge to all, if of satisfactory character. Address N. D. C. Hodges, 47 Lafayette Place, New York.]

To exchange, 1890 Seeger and Guernsey Cyclopedia, containing a complete list of the manufactures and products of the U. S., and address of first hands, cost $6. David R. Lewis, Saybrook, Ill.

For exchange—Nice specimens of Unios alatus, trigonus, parvus, occidens, anadontoides gibbosus, rectus, verucosus, gracilis coccineus, ventricosus, multiplicatus and plicatus cornutus. Margaritana confragosa, complanata, rugosa. Anadonta edentula, decora, corpulenta, and about 300 of the beautiful Ana. suborbiculata. Wanted: Unios from all parts of the world, and sea-shells. Address Dr. W. S. Strode, Bernadotte, Ill.

For exchange—minerals and fossils, including ores, corals, Mazon Creek nodules for other minerals and fossils or historical relics. Tertiary specimens desirable. Address T. N. Glover, Lock Box 19, Suffern, N. Y.

I wish to exchange Riley's Missouri Reports, either singly or full set, for Proceedings Entomological Society, Philadelphia, vols. 2 to 6 inclusive. Will also exchange Casey's Revision of the *Stenini* of N. A. and Horn's Revision of the *Tenebrionidae.* F. M. Webster, La Fayette, Ind.

I wish to exchange a fresh and complete set of Weiss and Spier's "Necropolis of Ancon" for other books, either new or second-hand, if the latter are in good condition. What have you to offer? Address Warren Watson, Kansas City, Mo.

Meteorites.—Mr. George F. Kunz, 11 to 15 Union Square, New York, or Hoboken, N. J., will buy or give in exchange for whole or parts of meteorites. Whole ones, undescribed ones, and entire falls especially desired.

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Carpentry and Building	1.00	4.25
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Christian Union, The	3.00	5.80
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Edinburgh Review	4.00	6.80
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Electrical World	3.00	5.80
Electrician and Electrical Engineer	3.00	5.80
Electrical Review	3.00	5.80
Engineering and Mining Journal	4.00	6.80
English Illustrated Magazine	1.75	4.55
Forest and Stream	4.00	6.80
Forum, The	5.00	7.80
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Harper's Bazar	4.00	6.80
Harper's Magazine	4.00	6.80
Harper's Weekly	4.00	6.80
Harper's Young People	2.00	4.80
Illustrated London News (Amer. reprint)	4.00	6.80
Independent, The	3.00	5.80
Iron Age (weekly)	4.50	7.30
Journal of Philology (Eng.)	2.50	5.30
Judge	4.00	6.80
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Macmillan's Magazine	3.00	5.80
Magazine of American History	5.00	7.80
Medical and Surgical Journal	5.00	7.80
Mechanical Engineer	2.00	4.80
Metal Worker	1.00	4.25
Microscope, The	1.00	4.25
Nature	6.00	8.80
North American Review	5.00	7.80
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Overland Monthly	4.00	6.80
Political Science Quarterly	3.00	5.80
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Popular Science News	1.00	4.25
Portfolio, The	7.50	10.30
Practitioner	3.50	6.30
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Puck	5.00	7.80
Puck (German)	5.00	7.80
Quarterly Review (London)	4.00	6.80
Queries	1.00	4.25
St. Nicholas	3.00	5.80
Scientific American	3.00	5.80
Supplement	5.00	7.80
Architect and Builders' edition	2.50	5.30
Scribner's Magazine	3.00	5.80
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